EUROPEAN
HYPERLOOP
WEEK

Scrutineering Checklist

Version 1.0 – 01-07-2026

Team Name: ____________________________

Prototype Summary: ____________________________

Prototype Mass: ____________________________

LV Battery Voltage: ____________________________

HV Battery Voltage: ____________________________

Inspection Status

Mechanical Inspection

Inspection by: ____________________________

Inspection Verdict: ____________________________

Electrical Inspection

Inspection by: ____________________________

Inspection Verdict: ____________________________

Control System Inspection

Inspection by: ____________________________

Inspection Verdict: ____________________________

INTRODUCTION

This document serves as a detailed scrutineering checklist for the prototype of teams wanting to demonstrate and/or operate at EHW 2026.

Each individual prototype (custom track, vehicle, etc.…) must pass the following technical inspections:

- Mechanical Inspection
- Electrical Inspection
- Control System Inspection

Teams are not allowed to dynamically test their prototype before all inspections have been passed.

Teams are not allowed to engage the High Voltage System of the prototype without the supervision of the scrutineer before having passed the Electrical Inspection.

Prototypes presented for technical inspection must be in "ready to demonstrate" condition.

MECHANICAL INSPECTION

MECHANICAL INSPECTION PREPARATIONS

Teams are required to have the following readily available for mechanical inspection:

- ☐ General availability of all required safety equipment as stated in the rules and regulations.
- ☐ A copy of their safety document and FDD including all datasheets and calculations. If some were missing in your initial safety document version, bring them now.
- ☐ Prepare their prototype in a finished state – changes or modifications after the scrutineering checks may lead to re-evaluation.
- ☐ Be familiar with the contents of this document.

VISUAL INSPECTION MECHANICAL

▶ All the inspections in this section will be performed with **all systems turned off** and **no pressurized fluids/gasses** being present in the prototype.

☐ SAFETY EQUIPMENT

1 ○ Two foam type fire extinguishers with valid inspection tags, or with an inspection date in the past year.
2 ○ Safety shoes for all team members working with heavy components rated S3 or better.
3 ○ The team demonstrates a good understanding of working safely and is taking appropriate measures while working on their prototype.

Comments: ____

☐ GENERAL MECHANICAL SYSTEM

▶ Critical (sub-)systems are defined as guiding systems (lateral & vertical), propulsion systems, (emergency) braking systems, all batteries / energy storage systems, load carrying structures, suspension systems, and high-voltage systems.

4 ○ All structural parts between or utilized in the critical (sub-)systems are designed with a safety factor higher than 2 under the worst-case load case. The parts are manufactured in accordance with the design as presented in the safety document and meet this safety factor criteria.

▶ Critical fasteners are defined as bolts, nuts, and other fasteners utilized in the critical (sub-)systems or utilized to connect critical (sub-)systems together.

5 ○ All threaded critical fasteners are at least 4 mm metric grade 8.8 (OEM parts 3 mm metric grade 8.8).
6 ○ All threaded critical fasteners are of the type hexagon bolts (ISO 4017, ISO 4014 or an equivalent standard.) or socket head cap screws (ISO 4762, DIN 7984, ISO 7379 or an equivalent standard) including their fine-pitch thread versions.
7 ○ All critical fasteners are secured from unintentional loosening using positive locking mechanisms. **See M.7. for accepted positive locking mechanisms.**
Any locking mechanism based on pre-tensioning, or an adhesive is not considered a positive locking mechanism.

8 ○ A minimum of two full threads projects from any lock nut.
9 ○ *If applicable*: All rotational systems (e.g. wheels, magnetic disks) are properly balanced.
10 ○ There are no dangerous sharp edges on the extremities of the prototype that could potentially harm people.

Comments: ____

☐ MAGNETIC SYSTEMS

11 ○ The team has implemented adequate procedures for handling and storing permanent magnet (assemblies).

12 ○ All mounted or stored permanent magnet (assemblies) are covered by a high-quality cover or storage container.

13 ○ The magnetic flux density does not exceed 1 mT anywhere on the surface of the covers or storage containers.

14 ○ The magnetic flux density does not exceed 0.5 mT at a distance of 1 meter or more from the covers or storage containers.

15 ○ Warning signs in accordance with ISO 7010-W006 are placed on (sub-)systems that utilize permanent magnets to indicate a magnetic field is present.

Comments: ____

☐ COOLING SYSTEM

16 ○ All cooling systems only use plain water or air as the coolant.

17 ○ The cooling system is not leaking and not at risk to start leaking once the system is operational.

18 ○ *If applicable*: If the cooling system has a vent, a properly sized catch-can is utilized to capture the excess cooling fluid.

Comments: ____

☐ COMPRESSED GAS SYSTEMS AND HIGH-PRESSURE FLUIDS

19 ○ All compressed gas systems do not exceed 50 bar.
Gas cylinders/tanks may exceed 50 bar if a pressure regulator is directly mounted onto them, limiting the output pressure to 50 bar or less.

20 ○ All parts of a compressed gas or fluid system are rated for the maximum operating pressure.
Components designed or manufactured by the teams themselves require a minimum safety factor of 2.

21 ○ Gas cylinders/tanks and their pressure regulators are of appropriate manufacture, certified and labeled as such.

22 ○ All parts of a compressed gas or fluid system are properly shielded from heat sources.

Comments: ____

CUSTOM TRACK VISUAL INSPECTION

☐ CUSTOM TRACK GENERAL

23 ○ The custom track is not longer than 50 meters.

24 ○ The custom track is fitted with a physical stop at the end of the track that is able to prevent the vehicle/prototype from exiting the custom track if it impacts the stop at maximum speed.

25 ○ The overall build quality of the track is good and the track is able to withstand strong weather conditions (wind, rain, etc.) and temperatures between 0 – 40 degrees Celcius.

26 ○ The custom track is not expected to move during a run, due to forces exerted on it.

27 ○ A safety perimeter is defined around the track and shielded with fences.

28 ○ If a tent is placed over the track, a two paths are always kept clear to ensure that all people are able to get out of the tent safely in case of an emergency. Exiting the tent must be possible from at least two sides.

29 ○ *If applicable*: If the custom track can create a low-pressure environment it includes a method to quickly repressurize the custom track.

30 ○ There are no dangerous sharp edges on the extremities of the custom track that could potentially harm people.

Comments: ____

☐ CRITICAL FASTENERS

31 ○ All threaded critical fasteners are at least 4 mm metric grade 8.8 (OEM parts 3 mm metric grade 8.8).

32 ○ All threaded critical fasteners are of the type hexagon bolts (ISO 4017, ISO 4014 or an equivalent standard.) or socket head cap screws (ISO 4762, DIN 7984, ISO 7379 or an equivalent standard) including their fine-pitch thread versions.

33 ○ All critical fasteners are secured from unintentional loosening using positive locking mechanisms. **See M.7. for accepted positive locking mechanisms**.

Any locking mechanism based on pre-tensioning, or an adhesive is not considered a positive locking mechanism.

34 ○ A minimum of two full threads projects from any lock nut.

Comments: ____

BRAKING SYSTEM INSPECTION

▶ If the prototype of the team has a propulsion system, the prototype is required to have an emergency braking system.

☐ BRAKING SYSTEM GENERAL

▶ To ensure the braking system is actuated at a safe distance from the end of the track, two switches should be implemented on the track/vehicle that each under all operating conditions trigger the emergency braking system (the "emergency brake switch")

35 ○ Two emergency brake switches are installed on the vehicle and track.

36 ○ The emergency brake switches are of the normally closed type and wired in series with the emergency braking system actuation signal (see example circuitry in rules and regulations).

37 ○ The emergency braking switches is actuated without programmable logic.

38 ○ The emergency braking system consists of at least two independent braking system mechanisms / brakes. They can be fed from the same power or air/fluid source but should otherwise be independent.

39 ○ Each independent emergency braking system is able to bring the prototype to a full stop from its theoretical top speed before the end of the track after triggering the emergency brake switch (see M.15) with a 10% safety margin.
Teams should demonstrate this with calculation (from their safety document).

40 ○ The emergency braking system is fully deployed without any voltage/power or air/fluid pressure present on the prototype and without the use of software. There should be no means for the team to not deploy the braking system without voltage/power or air/fluid being present.

41 ○ The braking force applied by each independent braking system is designed such that the net braking force is zero in all directions except opposite the direction of travel.

42 ○ It is taken into account that with more than one pod and/or a booster, the maximum distance/speed and location for emergency switches are changing depending on the design/combination

Comments: ____

☐ BRAKING SYSTEM DEMONSTRATION

▶ Teams are now expected to operate their braking system to demonstrate compliance with the rules and regulations, for this low-voltage and compressed gas/fluids may be used, but **no high-voltage**.

43 ○ With the braking system undeployed, turning off the low-voltage system directly deploys the braking system.

44 ○ In the case of power loss, can the system be vented? (Might be stuck on track/in tube)

45 ○ With the braking system undeployed, venting the compressed gas/fluid system directly deploys the braking system. (Simulating a leak).

46 ○ With the braking system undeployed, triggering one of the emergency braking switches directly deploys the braking system.

47 ○ With the braking system undeployed, opening the SDC by pressing a shutdown button directly deploys the braking system.

48 ○ The team is able to demonstrate that when the vehicle reaches the two switches in the infrastructure in all scenarios, both emergency braking switches on the vehicle will trigger.

Comments: ____

ELECTRICAL INSPECTION

ELECTRICAL INSPECTION PREPARATIONS

To be as prepared as possible we kindly ask teams to prepare the following prior to arriving at scrutineering (have it readily available):

- ☐ General availability of all required safety equipment as stated in the rules and regulations.
- ☐ A copy of their safety document and FDD including all datasheets and calculations. If some were missing in your initial safety document version, bring them now.
- ☐ Up to date schematics of the shutdown circuit and high-voltage system.
- ☐ Prepare their prototype in a finished state – changes or modifications after the scrutineering checks may lead to re-evaluation.
- ☐ Be familiar with the contents of this document.

VISUAL INSPECTION ELECTRICAL

▶ All the inspections in this section will be performed with **all systems turned off**.

☐ SAFETY EQUIPMENT & TOOLS

▶ All safety equipment must be rated for at least the max. voltage used by the team.

49 ○ Two pairs of High-Voltage insulating gloves, not expired or purchased in the past year.
50 ○ Insulated cable shears.
51 ○ Insulated screw drivers and any other tools that are required to connect or disconnect parts in the High-Voltage system including within any High-Voltage batteries.
52 ○ Face shield.
53 ○ Two HV insulating blankets of at least 1.0 m2 each.
54 ○ Safety glasses with side shields for all team members that might work on High-Voltage system or High-Voltage batteries.
55 ○ Multimeter with protected probe tips rated for 600 V CAT III or better.

Comments: ____

☐ ELECTRICAL SYSTEM GENERAL

56 ○ All High Voltage System Enclosures must be labelled with reasonably sized stickers according to ISO-7010-W012 and contain the text "High Voltage".

57 ○ All electrical systems have adequate overcurrent protection.

58 ○ If utilizing High Voltage, the prototype has two HV Measuring Points (HVMPs).

59 ○ The HVMPs are directly connected to the intermediate circuit capacitors even if the Manual Service Disconnect (MSD) has been disconnected or the High-Voltage battery is disconnected.

60 ○ All HVMPs are properly marked and use 4 mm shrouded banana jacks rated for 600V CAT III.

61 ○ A low voltage ground measuring point is installed which is properly marked and uses a 4 mm black shrouded banana jack.

62 ○ Resistance between HVMPs is required current limiting resistor + discharge resistor.

63 ○ The current limiting resistors can continuously carry the short-circuit current.

64 ○ Each Low-Voltage System has their own Low-Voltage System Master Switch (LVMS) that completely disables power to the Low-Voltage System.

65 ○ Each LVMS is marked "LV" and has its ON and OFF positions marked appropriately.

66 ○ If utilizing High-Voltage the prototype has a High-Voltage Master Switch (HVMS) that is part of the Shutdown Circuit (SDC).

67 ○ Each HVMS is marked with "HV" and a symbol according to ISO-7020-W012 and have its ON and OFF positions marked appropriately.

68 ○ All master switches are a mechanical switch of the rotary type and are direct acting, i.e. they do not act through a relay or logic.

69 ○ All master switches and measuring points should be located close to each other in a convenient position on the prototypes.

70 ○ For vehicles a system of four (4) shutdown buttons is installed featuring a shutdown button on the front, left, right, and rear of the vehicle. At least one shutdown button is easily accessible while the vehicle is on the track.

71 ○ For custom tracks featuring a Low Voltage or High Voltage system, a system of at least one (1) shutdown button is installed on the custom track (e.g. booster sub-system) such that it is easily reachable.

72 ○ All shutdown buttons have a minimum diameter of 40 mm, are red, and are of the normally closed type.

73 ○ All shutdown buttons are physically tested

Comments: ____

☐ LOW-VOLTAGE BATTERY

74 ○ The maximum voltage of the batteries is below 60 VDC or 50V AC RMS.
75 ○ The battery is properly fixed onto the prototype and has a rigid and sturdy casing.
76 ○ All batteries have adequately sized overcurrent protection (fuse), not more than 100 mm from ungrounded terminals.
77 ○ There is no visual damage or risk of shorting present within (or around) the battery.

▶ The checks below are required for battery packs based on lithium chemistry other than lithium iron phosphate (LiFePO4).

78 ○ The casing is built from fire-retardant material (see G.10).
79 ○ Includes overcurrent protection that trips at or below the maximum specified discharge current of the cells.
80 ○ Includes overtemperature protection of at least 25% of the cells, meeting (E.125), that trips when any cell leaves the allowed temperature range according to the manufacturer's datasheet, but not more than 60 deg Celcius, for more than 1 s and disconnects the battery.
81 ○ Includes voltage protection of all cells that trips when any cell leaves the allowed voltage range according to the manufacturer's datasheet for more than 500 ms and disconnects the battery.
82 ○ The team can display all cell voltages and measured temperatures, e.g. by connecting a laptop.
83 ○ Disconnecting one temperature sensor or one cell voltage measurement wire during technical inspection leads to BMS fault, disconnecting the battery.

Comments: ____

☐ INVERTERS (IF APPLICABLE)

▶ For the inspection of the inverters the inside of the inverters is required to be accessible, unless a fully off-the-shelf unit is used without any modifications.

84 ○ The positive and negative terminals of the inverters can easily be identified.
85 ○ The positive and negative terminals can not be plugged in incorrectly.
86 ○ The overall inverter assembly is of high build quality and the components in the inverter are properly fixed. Any mechanical connections are connected properly.
87 ○ There is no visual damage or risk of shorting present within (or around) the inverter.
88 ○ The inverter is properly fixed onto the demonstrator.

Comments: ____

☐ HIGH-VOLTAGE BATTERY

▶ For the inspection of the high-voltage battery the inside of the battery is required to be accessible.

89 ○ The positive and negative terminals of the batteries can easily be identified.

90 ○ The positive and negative terminals can not be plugged in incorrectly.

91 ○ The overall battery assembly is of high build quality and the components in the battery are properly fixed. Any mechanical connections are connected properly.

92 ○ Only fire retardant materials are used in the high voltage battery.

93 ○ If an alternative construction is used (E.110. & E.111.), teams can demonstrate equivalence in their safety document.

94 ○ If the HVBC is made from an electrically conductive material, the inside insulation barrier is adequately protected against penetration from conductive parts inside the battery.

95 ○ There is no visual damage or risk of shorting present within (or around) the battery.

96 ○ The high-voltage battery is properly fixed onto the demonstrator and lies within the primary structure.

97 ○ Each HVBC is removable from the prototype while still remaining rules compliant without the need to install extra components.
A dummy connector or similar may be used to restore the system's isolation.

98 ○ Every HVBC contains at least one fuse and at least two HVCs which are properly sized.

99 ○ The HVCs are mechanical relays of a "normally open" type.

100 ○ LVS must are not included in the HVBC except where inherently required.
Exceptions include the HVCs, HV DC/DC converters, the BMS, the Insulation Monitoring Device (IMD), the HVAL's green light circuitry, and cooling fans.

101 ○ High Voltage Battery Segments do not exceed a maximum static voltage of 120 VDC, a maximum energy of 6 MJ, or a maximum mass of 12 kg.

102 ○ Maintenance plugs allow electrical separation of all High Voltage Battery Segments. The separation must affect both poles of all segments including the first and last segment.

103 ○ The Maintenance plugs meet the following criteria:

- Not require tools to separate the segments.
- Be non-conductive on surfaces that do not provide any electric connection.
- Be designed in a way, that it is physically impossible to electrically connect them in any way other than the design intent configuration.
- Be protected against accidental reconnection.
- Be designed such that it is clearly visible whether the connection is open or closed. Electrically controlled switches must not be used.

104 ○ Each High Voltage Battery Segment is electrically insulated by the use of suitable rigid and fire retardant material, on top of the segment to prevent arc flashes caused by intersegment contact or by parts/tools accidentally falling into the HVBC during maintenance.

105 ○ High Voltage Battery segments are separated by internal vertical walls which extend from the bottom upwards until the lid / top.

106 ○ Pouch cells must be fixed using one or both of the large surfaces only. Each used surface must be fixed on at least 80 % . Tabs of pouch cells must not carry mechanical loads and must not press into the pouch.

107 ○ Cell temperature are measured at the negative terminal of the respective cell. The sensor used must be in direct contact with the electrically exposed negative terminal or less than 10 mm along the high current path, away from the terminal in direct contact with the respective busbar. It is acceptable to monitor multiple cells with one sensor if this requirement is met for all cells sensed by the sensor.

108 ○ All wires are rated for the maximum rated voltage inside the HVBC, including low-voltage wiring.

109 ○ The HVCs and the main fuse, are separated with an electrically insulated and fire retardant material, from the High Voltage Battery.

110 ○ A sticker according to “ISO 7010-W012” (triangle with a black lightning bolt on a yellow background) with the triangle side length of at least 100 mm and the text “Always Energized” is applied on every HVBC. The sticker also contains the text “High Voltage”.

111 ○ Each High Voltage Battery must be monitored by a BMS whenever the Low Voltage System is active, or the High Voltage Battery is connected to a charger. The team can display all cell voltages and measured temperatures, e.g. by connecting a laptop.

112 ○ Disconnecting a voltage sense wire or temperature measurement

Comments: ____

☐ HIGH VOLTAGE BATTERY CHARGER

113 ○ The battery charger is of high build quality and there is no visual damage to any of the wiring or risk of shorting present.

114 ○ The high voltage charging leads are orange.

115 ○ The team can explain how the BMS and IMD are active and monitoring while charging.

Comments: ____

☐ MANUAL SERVICE DISCONNECT (MSD)

116 ○ It is possible to disconnect at least one pole of any High Voltage Battery by quickly removing an unobstructed and directly accessible element, fuse, or connector. If multiple batteries are used in series one MSD is allowed to be used if all current goes through the MSD. It must be possible to remove the MSD without removing any panels. Rotary type MSD switches are allowed if they feature an interlock.

117 ○ Anyone is able to remove the MSD without the use of tools within 10 seconds while the prototype is on or in the track.

118 ○ The MSD is clearly marked with “MSD”.

Comments: ____

☐ LOW-VOLTAGE WIRING AND COMPONENTS

119 ○ There are no loose connections within the low-voltage (wiring) circuit.

120 ○ The High Voltage System and Low Voltage System circuits are physically segregated such that they are not running through the same conduit or connector, except for interlock circuit connections.

121 ○ There is no visual damage to any wiring or components.

122 ○ Wiring going to moving components have enough slack to allow for the movement and no wiring is under tension.

123 ○ Orange coloured wiring is not used for low-voltage wiring.

Comments: ____

☐ HIGH-VOLTAGE WIRING AND COMPONENTS

124 ○ All live parts of the High Voltage System are protected from being touched. This includes team members working on or inside the prototype. This can be tested with a 100 mm long, 6 mm diameter insulated test probe when the High Voltage System Enclosures are in place.

125 ○ Insulation material that is rated for the maximum voltage is used. Using only insulating tape or rubber-like paint for insulation is prohibited.

126 ○ Temperature rating for High Voltage wiring, connections, and insulation is appropriate for the expected surrounding temperatures but at least 85 ◦C.

127 ○ All High Voltage wiring is completed to professional standards with proper sized conductors and terminals and with adequate strain relief and protection from loosening due to vibration and High Voltage wiring is located out of the way of possible snagging or damage.

128 ○ All high voltage cables running outside the High Voltage Enclosures is enclosed in separate orange non-conductive conduit or use an orange shielded cable. The wiring (with conduit) must be securely anchored to the prototype, but not to the wire, at least at each end.

129 ○ Any shielded High Voltage cable has its the shield grounded.

130 ○ All connectors outside High Voltage Enclosures that do not require a tool to open have an interlock.

131 ○ All electric connections, including bolts, nuts, and other fasteners, in the high current path, of the High Voltage System are secured from unintentional loosening. Fasteners use positive locking mechanisms, see M.7, that are suitable for high temperatures.

132 ○ There are no soldered connections in the high voltage high current path unless for connections on PCBs, within motors/magnetic systems, the connected devices are not cells or wires, or there is additional mechanical securing against loosening.

133 ○ If the High Voltage System and the Low Voltage System are on the same PCB, they are on separate well-defined areas of the board, meeting the spacing requirements in rules and regulations.

Comments: ____

MEASUREMENTS & TESTING

☐ GROUNDING CHECKS

▶ All grounding checks will be performed with **all systems turned off**.

134 ○ All High Voltage System enclosures consist of either:

- grounded solid layer made of at least 0.5 mm thick electrically conductive material, aluminum or better, or
- be fully made out of electrically insulating materials having an isolation resistance of at least 2 MΩ, measured with a voltage of 500 V. The High Voltage System Enclosure must be rigid and must prevent possible mechanical penetrations. Protruding electrically conductive parts, such as fasteners or connectors, must be grounded.

135 ○ All conductive parts that require to be grounded (such as shielding, connectors, and High Voltage Enclosures) have with a resistance of <100 mΩ @ 1A to low voltage ground.

136 ○ Parts of the prototype which are or may become electrically conductive within 100 mm of any High Voltage component have a resistance below 100 Ω to Low Voltage ground.

Comments: ____

☐ INSULATION MEASUREMENT TEST

▶ All insulation measurement tests will be performed with **all systems turned off**.

▶ Determine the test voltage: 100V / 250V / 500V / 1000V (based on battery voltage).

137 ○ Measure the resistance at the test voltage between HV+ and LV GND, the resistance is much higher than 300 kΩ (or 500Ω/V).

138 ○ Measure the resistance at the test voltage between HV- and LV GND, the resistance is much higher than 300 kΩ (or 500Ω/V).

Comments: ____

☐ HIGH-VOLTAGE SYSTEM POWER-UP

▶ Connect multimeter between HV+ and HV-, measuring the voltage.

▶ Remove Manual Isolation Disconnect (MID).

▶ Team turns on their low voltage system(s).

139 ○ The High Voltage Active **Green** Light is on (continuously). The high Voltage Active **Red** Light is off.

▶ Team tries to power-up their high-voltage system.

140 ○ Battery does not turn on / second relay does not close, there is no voltage measured.

▶ Reconnect the Manual Isolation Disconnect (MID).

▶ Engage any shutdown button on the demonstrator (one by one).

▶ Team tries to power-up their high-voltage system.

141 ○ Battery does not turn on, no relay is switched, there is no voltage measured. (repeat for all switches)

▶ The team can now power-up their high-voltage system as normal.

142 ○ The system is pre-charged sufficiently (>95%) prior to second relay closing.
143 ○ The High Voltage System Active **Red** Light switches on when the voltage goes above 60VDC.
144 ○ The HVAL is placed on the prototype in a way that is clearly visible from any position around the prototype and in various light conditions.

▶ The team can now power-down their high-voltage system as normal.

145 ○ The measured voltage decreases in adequate time (<10 seconds) below 60VDC (discharging).

▶ Below are some additional inspection steps for the High Voltage Active Light:

146 ○ The HVAL is not used for any other purposes.
147 ○ The red light and green light detection circuits act through hardware, do not require software and operate independently.
148 ○ The green light circuit is located inside the HVBC.
149 ○ The green light circuit detection uses the actual mechanical states of the HVCs.

Comments: ____

☐ HIGH-VOLTAGE SYSTEM SHUTDOWN

▶ Connect multimeter between HV+ and HV-, measuring the voltage.

▶ The team can now power-up their high-voltage system as normal.

150 ○ Engaging any shutdown button or master switch powers off the high-voltage system (relays) and system discharges to <60VDC in <10 seconds (including software switches). (repeat for all switches)

151 ○ Un-pressing any shutdown button does not result in re-enabling of the high voltage system.

▶ The team can now power-up their high-voltage system as normal.

152 ○ Check if Manual Service Disconnect (MSD) can be switched off under load.

153 ○ Removing the MSD powers off the high-voltage system (relays) and system discharges to <60VDC in <10 seconds.

Comments: ____

☐ INSULATION MONITORING DEVICE (IMD)

▶ Test Resistance: ~110 kΩ.

▶ The team can now power-up their high-voltage system as normal.

▶ The test resistance is connected between HV+ and LV GND.

154 ○ The IMD triggers and the relays open within 30 seconds.

155 ○ A red indicator light shows that there is no proper insulation.

156 ○ The system discharges to <60VDC in <10 seconds.

157 ○ Removing the test resistance does not result in reactivation of the high-voltage system.

158 ○ Enabling the HV system through software does not work, without resetting the IMD fault with a switch or by deactivating the LV system.

▶ The team can now power-up their high-voltage system as normal.

▶ The test resistance is connected between HV- and LV GND.

159 ○ The IMD triggers and the relays open within 30 seconds.

160 ○ A red indicator light shows that there is no proper insulation.

161 ○ The system discharges to <60VDC in <10 seconds.

162 ○ Removing the test resistance does not result in reactivation of the high-voltage system.

Comments: ____

CONTROL SYSTEM INSPECTION

CONTROL SYSTEM INSPECTION PREPARATIONS

To be as prepared as possible we kindly ask teams to prepare the following prior to arriving at scrutineering (have it readily available):

- ☐ General availability of all required safety equipment as stated in the rules and regulations.
- ☐ A copy of their safety document and FDD including all datasheets and calculations. If some were missing in your initial safety document version, bring them now.
- ☐ Prepare their prototype in a finished state – changes or modifications after the scrutineering checks may lead to re-evaluation.
- ☐ Be familiar with the contents of this document.

CONTROL SYSTEM INSPECTION

This will be done for every prototype. Two pods and an active track with a booster section are 3 separate prototypes which should be checked accordingly (as applicable)

☐ SIGNAL READ OUT

▶ Team turn on vehicle (low-voltage only) in idle state.

163 ○ The control interface of the prototype has an emergency button that requires one click or keystroke.
164 ○ Send configuration from ground station
165 ○ Configuration from ground station always send up-to-date? Maybe outdated or old values? How is this indicated?
166 ○ Are there any values just for monitoring and not for a critical failure transition? If so, why?

▶ The values below are required to update in the control interface at least every second.

167 ○ The control interface displays the HVAL Green Light Status.
168 ○ The control interface displays the HVAL Red Light Status.
169 ○ The control interface displays the IMD Status.
170 ○ The control interface displays the High Voltage BMS Status.
171 ○ The control interface displays the Emergency Braking System Status.
172 ○ Safe range of values is indicated
173 ○ UI does not display outdated values
174 ○ The demonstrator enters fault state after reading out-of-range values
175 ○ Plausibility checks for parameter input?
176 ○ Plausibility checks for sensor output?

▶ The values below are required to update in the control interface at least every 500ms.

177 ○ The control interface displays for every BMS the total pack voltage.
178 ○ The control interface displays for every BMS the maximum cell voltage.
179 ○ The control interface displays for every BMS the minimum cell voltage.
180 ○ The control interface displays for every BMS the maximum cell temperature.
181 ○ The control interface displays for every BMS the minimum cell temperature.
182 ○ The control interface displays for every BMS the total pack current.
183 ○ The control interface displays the DC-link voltage (for high-voltage systems).

Comments: ____

☐ COMMUNICATION SYSTEM

▶ Team turn on vehicle and transition the vehicle into (HV) Active State.

▶ The team or scrutineer will disconnect the communication on the ground station side. Simulating loss of communication.

184 ○ The vehicle should immediately (<100 ms), on its own change to Emergency State and open the SDC. This can be verified by High Voltage system discharging or other indicators on the vehicle.

Comments: ____

☐ CODE SAFETY (GROUND STATION & EMBEDDED)

▶ These Tests include possible reviews of certain code sections. Provide rational/prove for the mitigation/non-existance of the following possible errors:

185 ○ Memory and Data errors (I.e. Stack/Heap, Overflows, Out-Of-Bounds, Invalid pointers, non initialized variables, memory corruption)

186 ○ Synchronisation and parallelism (I.e. race conditions, interrupt problems, Synchronisation, Conflicts, Deadlocks)

187 ○ Logic (I.e. Undefined behavior, Compiler optimization, other logic failures – proved by rational or software tests)

188 ○ Hardware/Runtime (I.e Voltage drop, EMV, Watchdog, Sensor, different clocks and their synch)

189 ○ Communication (I.e. message/package loss, data is corrupted, wrong sensor data, bitflip, WIFI/network latency)

Comments: ____

☐ STATE MACHINE

▶ Team turn on vehicle (low-voltage) in idle state.

190 ○ Engaging the propulsion or guidance through the control interface results in no change or an error.

191 ○ A data cable carrying any of the system critical signals is disconnected on the vehicle (e.g. data to inverter/converter or a distance sensor. This should result in the vehicle transitioning into emergency state (per C.4.).

▶ Team turn on vehicle (low-voltage) in idle state.

192 ○ Pressing the emergency button in the control interface transitions the vehicle into emergency state which leads to braking.
193 ○ SDC and emergency braking system is latched
194 ○ How does system indicate that it has reached the end of a run? (Is there a braking timer additionally?)
195 ○ Possible drift of navigation system handled properly?
196 ○ How does system indicate that it has come to a stop?
197 ○ Is driving backwards possible?

► On the guidance of the scrutineer the team will now transition its vehicle from Idle State to (HV) Active State to Demo State and Emergency State where the following is checked.

198 ○ The guidance or propulsion system can only be activated in Demo State.
199 ○ The braking system can only be retracted / undeployed in Demo State.
200 ○ All values presented in the control interface are within acceptable and expected bounds, e.g. high voltage is measured correctly and critical signals from propulsion system is displayed correctly.
201 ○ Throughout the states the correct statuses are shown in the control interface.
202 ○ No braking while accelerating is possible?
203 ○ Other parts of the system (booster, other pod, ground station), etc. should be disconnected which should lead to a fault state
204 ○ For several systems (booster, other pod): combined state machine tests possible
205 ○ For booster: is it possible that pod is in booster with open brakes and in a non active state, so it might be moved by booster without being in the correct state of pod?
206 ○ For several systems (with booster and/or other pod: Does the maximum speed/traveled distance and emergency braking distance (location of emergency switches) is still calculated correctly?
207 ○ For several systems (booster, other pod): Combined emergency combinations from all states of both possible
208 ○ Are long/endless running loops NOT possible? How is the mitigation?
209 ○ Two prototypes: if one pod is too close up to a certain distance, do both break? (Not only the first pod accelerating too fast but also the second pod might accelerate in the wrong direction? Sensors on both Pods into the direction of other pod?)
210 ○ Theoretical max speed > programmed max speed (which initiates the brakes) not possible?
211 ○ What happens in case a task/thread freezes?
212 ○ How is the risk addressed, that if the UI render and event thread freezes, the Pod is able to brake/brake command from UI can still be sent?
213 ○ Is there a heartbeat sent from the ground station to the pod and vice versa?
214 ○ How is the problem addressed if the UI thread freezes and you might have a mutithreading application, the heartbeat thread is not still sending a positive feedback?
215 ○ Are Watchdogs in place if a microcontroller misbehaving/not changing to the correct state, that it will eventually be in a safe state?
216 ○ After there is an error that will lead manual/automated to a disabled HV system, might a return to the state before (without error, system returns to state before error) might automatically lead to HV enabled again (not latched)?
217 ○ If possible: system is moved by hand to indicate that navigation system is working correctly
218 ○ Manual state transitions for system possible?
219 ○ For several systems (booster/other pod): Can one pod be pushed into another by the booster?
220 ○ For several systems (booster/other pod): Can one pod be pushed into the wrong direction by the booster (usually located at one site of the track) into an end stop?
221 ○ What happens if booster and pod are activated at the same time? Taken into account for max speed or not possible?

▶ On the request of the scrutineer more tests and checks can be performed to ensure the team has safe control over the prototype.

Last System tests:

222 ○ Small demo is working or at least system is in safe state (for further testing)

223 ○ Agreed on: After Control TI is done, small code changes are possible, not safety critical, and should be documented and in review shortly addressed from time to time with Scrutineer for explanation

224 ○ Agreed on following set of parameters that are allowed to be used for further testing:

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Comments: ____